FULL-LENGTH ARTICLE

GeoGebra-supported learning and secondary school students' motivation for learning geometry

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ABSTRACT

Technology-based geometry instruction is a strategy for teaching geometry that can encourage students to associate real-life situations with geometrical concepts. Technology-assisted instruction is generally said to be beneficial; however, its impact on motivation is up for debate. In light of this, a quasi-experimental, non-equivalent research design was conducted in Shambu Secondary Schools, East Wollega Zone of Oromia Regional State, Ethiopia, to investigate GeoGebra-supported learning on students' motivations towards learning geometry. Three instructional approaches were used: the GeoGebra-supported convectional method (GSCM), the GeoGebra-supported collaborative method (GSCOM), and the conventional method (CM) established for this purpose. Three schools were purposefully selected and randomly sampled in to one control group and two experimental groups. For ten weeks of learning, experimental groups I was instructed in (GSCOM) (n = 42) and experimental groups II were instructed in (GSCM) (n = 42), while the control group were (n = 44). The components of the pre- and post-motivation Likert scale questionnaire, including intrinsic, extrinsic, task value, and self-efficacy, were used to collect data from 128 students. Paired sample t-tests, Scheffe's posthoc test, and ANOVA were used to analyze the data. The study's findings indicated that there is a significant mean variation in the three groups' students' motivation for studying geometry. This indicates that secondary school students who were exposed to the GSCOM had better motivation than others who were exposed to the GSCM and CM toward learning geometry. Based on the results, it was recommended that secondary school mathematics teachers better use these potential approaches to improve their students' motivation to learn geometry.

Keywords: GeoGebra-supported collaborative method, geometry, student motivation, secondary school mathematics

INTRODUCTION

Geometry has been part of the curriculum and is an important area of mathematics since the 19th century (Jones, 2003). It has a long history and is extremely associated with the growth of mathematics and numerous progressives. The backdrop of geometry offers a rich cultural and historical background for performing mathematical operations (Jones, 2003). In the historical period, geometry was truly considered the earth's measurement (Dillon, 2018). Nowadays, geometry is part of the basic knowledge of specific professions in the domain of STEM (science, technology and mathematics).

Geometry gives students a variety of fundamental skills such as problem-solving skills, reasoning skills, logic skills, and critical thinking skills (Tatar & Zengin, 2016; Dimla, 2018). These skills are useful in life and in a variety of scientific fields. Moreover, geometric concepts serve as a basis for other mathematical disciplines like algebra, calculus, trigonometry, and statistics. It plays a significant role in human life through daily activities in architecture, art, engineering, physics and technology including its application in computers, robotics, and video games (Singh, 2022).

Geometry, particularly plane and solid geometry, can be challenging to teach and learn using traditional tools like paper and pencil. Students often struggle with understanding geometric concepts due to the static nature of diagrams in textbooks. This difficulty is compounded by the abstract nature of many geometric concepts, which can lead students to find the subject rigorous and challenging. According to Usiskin (1982), many students have difficulty in grasping fundamental geometric concepts and may prefer to leave geometry without learning basic geometric terminology. Several factors contribute to students' struggles in learning geometry, including lack of motivation, limited teacher-student interaction, poor problem-solving skills, and ineffective teaching methods (Adolphus, 2011;Udousoro, 2011, Dimla, 2018; MoE, 2017).

Mathematics and geometry learning competency are determined by the three most influential factors, including motivation, teaching methodologies, and teacher proficiency in mathematics education (Gunaseelan & Pazhanivelu, 2016). Motivation plays a critical role in mathematics and geometry achievement (Gunaseelan & Pazhanivelu, 2016). It is also a key factor in enabling students to succeed academically and fostering students' self-regulated learning. Research conducted by Broussard & Garrison (2004) revealed that students' motivation towards learning geometry is highly correlated with achievement in mathematics at elementary schools. Moreover, technology and students motivation toward learning mathematics are positively interrelated (MacLuckie, 2010).

The development of concepts, critical thinking, learning strategies, and achievement in mathematics education all depend heavily on the motivation of the students. Self-determination, self-efficacy, personal relevance, anxiety, and intrinsic motivation are the internal forces that cause someone to continue engaging in an activity. Researchers have proposed that there are various components of motivation from a variety of perspectives (Liu & Lin, 2010; Cavas, 2011). Gan et al.(2023) for example, suggested intrinsic, extrinsic, self-efficacy and task value as components of motivation that could be connected to scientific academic success. These interrelated components of motivation enhance students' more stimulating, focused, and long-lasting scientific learning practices.

Intrinsic motivation: It is the act of participating in or enjoying an activity due to its inherent fulfillment for its own sake rather than in response to external pressure. Consequently, intrinsic motivation is associated with high levels of effort and task performance (Ryan & Deci, 2000; 2017). A student who is intrinsically motivated by geometry works on the subject with the intention or goal of learning more about it in order to improve his or her understanding and abilities for their own benefit, and they genuinely appreciate learning new things. Students who lack motivation will not perform to their full potential because they lack the motivation to seek out educational challenges (Wagner, 2007). A greater degree of intrinsic motivation is associated with enhanced conceptual understanding, better recall, other positive classroom behaviors, and a higher degree of overall academic achievement in students (Augustyniak et al., 2016).

Extrinsic motivation: It is the desire or pressure to engage in a particular activity based on the prospective benefits from outside incentives (e.g., grades, prizes, comparing oneself to others' performance). Extrinsically motivated learners, who study geometry with goals other than academic success and who, on the continuum, are more inclined toward active personal commitment can be driven to behave mainly by the potential reward. According to Onu et al.(2019), certain people may respond better to extrinsic motivation than intrinsic motivation. In some circumstances, this kind of incentive might also be more appropriate. For certain individuals, the benefits of outside rewards are plenty to motivate them to keep producing excellent work.

Self-efficacy: Self-efficacy is defined as individuals believing in their abilities to follow a plan of action required to complete an activity (Bandura, 1977). Students are motivated to participate in, perform, and complete a learning activity when they already believe they are capable of doing it. The motivation to learn mathematics is also influenced by self-efficacy. Higher levels of mathematical self-efficacy lead to students who are better motivated to engage in problem-solving activities, creativity, and competitiveness than lower ones are (Saadati & Celis, 2023). According to Toharudin et al.(2019), students who possess high self-efficacy persevere and successfully finish projects, whereas those with low self-efficacy avoid challenging tasks.

Task value: Expectancy-value expresses that students' motivation to learn mathematics has two components. These are the worth attached to the task and the standards for achievement. This study considers only task value. Task value refer to the motivation for participating in academic activities (Wigfield & Eccles, 1992). The value assigned to a task's significance, enjoyment, and utility is also known as task value (Lee et al., 2014) Similar to success expectations, task values are proposed as important closest predictors of academic achievement and course performance in educational environments (Wigfield & Eccles, 2002).

Instructional methods also have a considerable impact on students' motivation towards learning geometry and mathematics. Teaching methods that are flexible and actively engaged with students provide higher motivation and meaningful learning in mathematics than teaching methods that do not involve students in the classroom. The study conducted by Laal & Ghodsi (2012) revealed that students instructed with a collaborative learning approach were highly motivated compared to those taught using conventional methods. In collaborative learning, students work together and share their knowledge and experience in groups to learn and apply a subject's knowledge to solve difficulties, finish activities, or accomplish objectives. Through this interaction, students are able to achieve higher-order thinking skills and keep information longer than individual learning (Amalia, 2018). On the other hand, computer-supported instruction provides a setting for students to interact about geometric topics in small groups and solve mathematical problems together (Takači et al., 2015). In the current study, a student-centred learning approach, collaborative learning with technology, was investigated in relation to motivation.

Utilizing technology in the instruction of geometry enables students to construct, reflect, and understand topics in simple ways, all of which have an impact on students' academic achievement. According to the study made by Phonguttha et al. (2009) , computers are encouraged in mathematics classrooms since they are significant in educational contexts. Particularly, using various mathematical software helps students understand the concept, develop confidence, and improve their motivation for the subject area (Zulnaidi & Zakaria, 2012). There are different kinds of instructional technology tools that are widely used in teaching mathematics (Hohenwarter & Fuchs, 2004). GeoGebra is among these technological tools. It plays a major role, thus educators of mathematics are encouraged to use it as a suitable technology from elementary school to higher education, across ability levels, and in various content areas.

GeoGebra is open-source and dynamic multi-platform mathematical software that can be used as a medium for learning mathematical contents such as geometry, calculus, and algebra (Hohenwarter & Fuchs, 2004). According to Tatar & Zengin (2016), teaching with the support of GeoGebra software produced a lively and dynamic learning environment, offered visualization and opportunities for students to practice and learn mathematics. Moreover, numerous empirical studies have shown that GeoGebra is used as a tool for geometry presentation, visualization, construction, and sketching in mathematics exploration, allowing students to expand their own understanding (Hohenwarter & Fuchs, 2004; Saha et al., 2010 ; Vasquez, 2015). Particularly, it supports the construction of figures utilizing lines, points, and every conic segment. Additionally, it has typical capabilities to calculate area, volume, angle, and length measurements of solid and plane figures, and it displays equations of circle and conic sections, lines, and slopes during construction. That is the reason why GeoGebra is a good choice for multiple representations of mathematical objects.

Moreover, there are different research findings about the use of GeoGebra and its effect on several factors like conceptual understanding and achievement. Dogan & Içel (2011) indicated that mathematical achievement and students' attitudes about studying triangles both improved when GeoGebra is used in the classroom. Chimuka (2017) also revealed that using GeoGebra software in instruction improves students' understanding, geometric reasoning, and thinking skills and motivates them to learn circle geometry. Using GeoGebra as a teaching mathematics tool enhanced students' perceptions and mathematics achievement in a classroom (Bedada, 2021). According to Acharya (2020), students who utilized GeoGebra showed an overall increase in engagement, and achievement when learning geometry, including the features of a parallelogram. Furthermore, the research conducted by Saha et al.(2010) demonstrated that the use of computers to support conventional classroom instruction is more effective than using the conventional approach alone. The research conducted by Putra et al. (2021) indicates that incorporating GeoGebra into mathematics instruction can enhance the understanding of the concepts of rectangle area and perimeter.

As discussed above, many researchers have studied the use or effect of GeoGeba software in the instruction of mathematics. To our knowledge, there is no research done to examine the effectiveness of GeoGebra integrated with an active method of learning on students' motivation in learning geometry in Ethiopia. Moreover, the integration of GeoGebra software with various teaching and learning geometric concepts, including collaborative and conventional learning approaches in secondary schools has not received significant attention in Ethiopian education settings (MoE, 2020; Bedada, 2021). Therefore, this study was aimed at exploring GeoGebra -assisted learning and students' motivations for learning geometry at Shambu Secondary Schools, East Wollega Zone of Oromia Reginal State, Ethiopia

Statement of the problems

Lack of motivation to learn mathematics, particularly geometry, is a recurrent problem in Ethiopian secondary education (MoE, 2017;2020). A lack of motivation to learn mathematics leads to bad school behavior and often negatively affects student achievement. Students lack motivation, and their bad school behavior in learning mathematics is the result of ineffective teaching methods (Popovska Nalevska & Kuzmanovska, 2020). In other words, a portion of the reason for students' low motivation to learn can be attributed to the inadequate choice of learning activities that match not only mathematics but also the distinctive characteristics of each student. Moreover, the concept of geometry learning is, in its nature, abstract and challenging to deeply understand the subject. This problem may result in low motivation for learning geometry among secondary school students. Furthermore, lack of motivation, absence of technology or its improper use, and visualization abilities are a few more elements that contribute to the ineffective acquisition of geometric concepts (Dereje et al., 2023).

Ethiopian students at all grade levels consistently perform below grade level in mathematics and geometry (MoE, 2017, 2018). By using national examinations to assess the efficiency of secondary schools, many students score very poorly due to a lack of teaching and learning materials, lack of motivation, and the use of rote memorization of the mathematics curriculum. According to Ethiopia's third national learning assessment (ETNLA, 2017), students in secondary schools do poorly in mathematics, particularly in geometry, when compared to other areas of study. For instance, the mean score of the 10th grade geometry course in 2017 was 38.18, which is far below the achievement level (50%). One reason why students perform poorly in mathematics has been found to be a lack of motivation. Motivation for learning mathematics is related to academic achievement, problem solving, and understanding the content. Students' ability to solve problems and have an in-depth understanding of mathematics is both greatly affected by their motivation in their mathematics studies (Mehdiyev & Vos, 2010).

The teaching and learning strategies employed by the teacher are the main factors contributing to the low achievement of mathematics in general and geometry in particular among secondary school students. The dominant pedagogical approach that characterizes secondary school education is the convectional teaching method, which involves heavy talking by the teachers, primarily in the form of material presentations or student lecturing (textbook, lecture notes, lectures, assignments, final exam). This strategy, as several studies have shown, continues to be used by teachers in Ethiopian secondary schools (Semela, 2014; MoE, 2015; Bekele, 2018). Conventional teaching method may not be an effective method to develop students' meaningful learning skills such as critical thinking skills, problem-solving skills, understanding of mathematical concepts, and collaborative learning skills (Cronhjort et al., 2013; MoE, 2020). Students have not had enough opportunities to create their own learning using conventional educational techniques.

Therefore, it would appear that the way mathematics, and particularly geometry, is taught and learned in the classroom influences students' motivation to learn the subject. Due to their direct and substantial influence on students' motivation, instructional approaches must take precedence (Abera, 2015). Furthermore, according to Kotu & Weldeyesus (2022), secondary school students learning mathematics are influenced by inadequate teaching methods and low motivation. Student motivation is changed when the teaching delivery is changed. Thus, in order to foster meaningful learning, secondary schools need to adopt new and innovative methods for teaching and learning geometry. Teachers in secondary schools must implement learning strategies that could increase their students' motivation to learn geometry. Besides, to provide students with motivation skills in teaching and learning geometric concepts, it is critical to use a student-centered approach. Thus, collaborative learning is a kind of student-centered learning where students, with the help of the teacher in the classroom, actively participate and create their own knowledge through peer discussion (Laal & Ghodsi, 2012). Furthermore, the teaching and learning process in geometry requires the integration of educational technologies since the subject matter includes abstract concepts found in statements and theorems (Wong et al.,2011). Research suggests that the integration of technology-supported learning with relevant methods of teaching might enhance the quality of teaching and learning (Charles-Ogan & George, 2015; Gemechu et al., 2018). While the use of technology in Ethiopian secondary schools for purposes of learning was formerly restricted, students now have access to computers, mobile devices, and the internet.

Therefore, since there was no study conducted on the impact of GeoGebra-supported instructional methods, the main focus of this study was to investigate the effect of this technology integrated with collaborative and conventional learning approaches in secondary school geometry. Accordingly, this study was conducted to determine the effect of GSCM, GSCOM and the conventional method only on students' motivation in geometry; and to examine the motivation and components of motivation of those students taught with GSCM and GSCOM approach.

Research Questions

1. Is there a significant mean difference on students' post- motivation (with its component of motivation) towards learning of geometry among the group?
2. Is there a significant mean difference between pre- and post –motivation (with is its component of motivation) towards learning of geometry in a group?

MATERIALS AND METHOD

Research Design

In this study, a quasi-experimental pre- and post-test with a non-equivalent multiple-group research design was used. With this design, the study may be carried out in a natural setting, and individuals can be assigned at random. The study uses three intact groups: one is utilized as a control group, and the other two are the treatment groups. Accordingly, the first experimental group (EG1) was instructed by GeoGebra supported with the collaborative approach (X1), the second experimental group (EG2) was instructed by GeoGebra supported with the conventional approach (X2), and the control group (CG) was also taught with the conventional approach. In a control group, no intervention was taken, and textbook-based direct instruction was used to continue the instruction program. The effects of using the GSCOM and GSCM methods on students' motivation for geometry were investigated through a quasi-experimental research design, leading to the following research design for this study.

Table 1. Quasi-experimental research design Layout

Groups		Intervention	
Experimental Group1(EG1)	Pre test	GSCOM	Post test
Experimental Group 2 (EG2)	Pre test	GSCM	Post test
Control Group (CG)	Pre test	CM	Post test

Where, GSCOM= GeoGebra supported with collaborative method; GSCM=Geogebra supported with conventional method; CM= Conventional method.

Participants and Sampling technique

This study was conducted at three governmental secondary schools located in Shambu town, Oromia Region State, Ethiopia. Grade 10 students were the target of the study because mainly geometry is taught there. Three schools were selected for the intervention using purposive sampling, taking into account variables such as school infrastructure, computer accessibility, teacher qualifications, and previous experience. One mathematics teacher was specifically chosen from each of the three schools, and a section of grade 10 students from those teachers' classrooms was chosen at random in each school. One hundred twenty-eight grade 10 students, including 73 male and 55 female students, participated in this study. In the three schools, there are 18 sections of grade 10 students. Following the selection of all three sections, two were assigned at random to be the treatment group and the other as the control group. Each of the three sections' students participated in the study, and these schools have similar conditions. In this case, Abishe Gerba Secondary School (GSCOM = 42 students) was sampled as in experimental group 1, Shambu Secondary School number one (GSCM = 42 students) was sampled as in experimental group 2, and Shambu Secondary School number two (CM = 44 students) was sampled as a control group school. Under units 5 and 6 of the 10th grade mathematics textbook, the intervention covered the following topics: theorem triangles, more in circles, special quadrilaterals, regular polygons, and solid figures. Hence, the intervention took about ten weeks (five periods per week)in the second semester of the academic year.

Instrument for Data Collection

The motivation scale questionnaire (MSQ), which consisted of four parts, was utilized for this investigation. The questionnaires adapted from Liu & Lin (2010**)** were modified to include intrinsic, extrinsic, task-value, and self-efficacy scales. The objective of the pre-motivation questionnaires given to the students is to identify the understanding of students' motivation to learn mathematics generally, but the post-motivation questionnaires are to identify the understanding of students' motivation to learn geometry specifically utilizing GeoGebra software-supported learning. The items were scored using a Likert-type, five-point scale with four components. Students were asked to choose one of the numbers among 1 to 5 scales, where: 1-strongly disagree, 2-disagree, 3-neutral, 4-agree, and 5-strongly agree.

Validity and Reliability

The content validity and face validity of the training materials of the intervention and questionnaire were examined by two mathematics teachers from secondary school, supervisors, experts, and a PhD candidate in mathematics education. Following an expert examination, the initial 42-item scale was revised to include only 36 items. The aim of a review is to check the consistency of items, adequacy, clarity, and representation for measuring motivation in learning mathematics. Before being used in the main study, the test items were piloted in the same population in order to evaluate their reliability.

A pilot study to estimate reliability offered the GMQ to 55 students selected from Sekela Secondary School who finished the course in geometry. After the pilot study, 31 questions remained used to assess students' motivation towards geometry by removing items with poor associations between them. The questionnaires consist of four subscales: intrinsic, extrinsic, task value, and self-efficacy.

The reliability of the pre-motivation item scale was checked using Alpha Cronbach using SPSS version 26. The result reliability of the pre-motivation scale was α = 0.819 .The post-motivation item was a follow-up to the pre-motivation component of the GeoGebra supplemental approach to learning. As a result, 31 items with an acceptable reliability coefficient were utilized for the actual investigation.

The researcher designed a lesson plan on the topic of the special quadrilateral (rhombus)-based 5E instructional model, which comprises five stages, including engage, explore, explain, elaborate, and evaluate (Ceylan & Ozdilek, 2015) . This 5E strategy is intended to encourage students to study mathematics by enjoying their interest in new concepts and involving them in the learning process through phased lessons.

Engagement stage: The first phase of the 5E model is used to introduce students to the topic. In this stage, the teacher asks open-ended questions to assess the students' prior knowledge and inspire them to become actively involved in learning about the rhombus.

Exploration stage: In the second phase, students are grouped into fives, work together and each group is expected to share their ideas with others. The activities require the use of GeoGebra software skills such as drawing rhombus, measuring (angle, side, diagonals, etc), classifying, recording, and defining operationally. Teachers can act as consultants to their students to prompt questions.

Explanation stage: In this stage, the students will return to the entire group setting and compare their work with that of the other groups. Teacher asks students what they learned during the Explore phase. In light of the students’ responses, the teacher explains the topic. Students identify properties of rhombus using GeoGebra work results.

Evaluation stage: The final phase is a period of reflection to determine learning outcomes. The teachers can use formal or informal assessments related to rhombus like self-assessments, exercise, or test to have students demonstrate their understanding.

Here is a sample of a classroom project constructed with GeoGebra for GeoGebra class sctivity:
Activities – Using GeoGebra software to investigate the properties of the rhombus (for EG1)
Explore- Draw a quadrilateral and diagonals

1. Draw a line $\overline{AB}$ and a line parallel to $\overline{AB}$ through point C.
2. Hide point B.
3. Construct a circle with center A and radius $\overline{AC}$
4. Label point D at the intersection of the circle with centers A and line$\overline{AD}$.
5. Construct a circle with center D and the line passing through point C intersect at E.
6. Draw a quadrilateral by connecting A, C, D, and E. Hide the circles.
7. Measure the length.

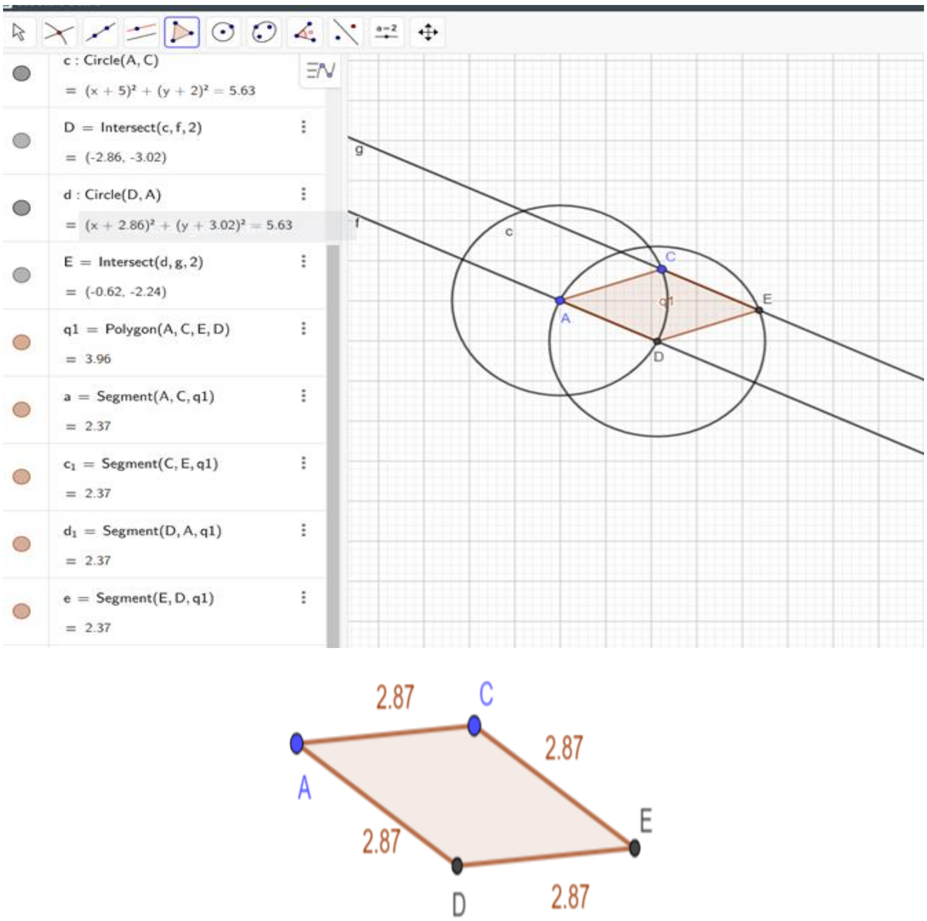

Figure 1. GeoGebra screen view construction of Rhombus

Procedure of interventions

Prior to administering any treatments to the experimental groups, all groups conducted pre-motivation questionnaires. The purpose of this pre-motivation questionnaire is to determine whether students have the same motivation for mathematics learning. One week of training was given to the teachers who implemented the intervention, the students of both experimental classes, and two ICT laboratory technicians. The content of the training was how to use GeoGebra software, how to implement the material developed for teaching experimental group, how to develop and use the 5E model lesson plan, and so on. The CG teacher was not trained and followed the usual student textbook. Both experimental groups, EG1 and EG2, were given 10 weeks of geometry instruction using a learning method supported by GeoGebra software. The intervention took about ten weeks.

GeoGebra-supported collaborative approach group (EG1) was used to teach geometry lessons using GeoGebra software in the form of a discussion. As part of this method, groups of students were formed of four to five individuals to do every activity, such as exercise, work sheet, and assignment, in groups. The activities in this study included viewing geometric shapes, dragging and manipulating them, and utilizing geometry to analyze and posit hypotheses. Teachers' roles must shift such that they serve as facilitators, giving students chances to assess how well they now grasp the material being taught. Group EG2 was used to teach a geometry lesson using GeoGebra software and a text book, with out-of-group discussion in the whole class. In this method, the teacher introduced a concept at the beginning of the class and then used GeoGebra software to explain the material. The researcher monitored the intervention and talked with the teachers on how to modify the exercise to ensure the use of the transferable practices between topics.

In a convectional classroom, the teacher would provide a concise explanation along with the definitions, geometry rules, and formulas. The teacher mostly used lecture techniques, but students also engaged in inquiry centered on the teacher's questions. The teachers did not use any technology or manipulative, and GeoGebra was not used by the students to help them understand the relationships between ideas. The majority of students utilized brief notes from their teacher-provided exercise book to respond to issues because even the geometry diagram and figure in their textbooks were not taken into consideration for clarity and visualization. In general, the instructor concentrated on the textbook's lower-level learning-focused questions.

Finally, all groups conducted post-motivation questionnaires that measured their motivation for geometry concepts once the interventions were finished. This was done at the end of ten weeks to determine which group was performing better in terms of motivation for learning geometry. At both the pre-motivation and post-motivation levels, students completed the questionnaire on their own.

Method of data analysis

The Statistical Package for Social Sciences (SPSS) version 26 software was used to analyze the raw data from the motivation Likert scale using descriptive and inferential statistics in order to determine the effects of GeoGebra-supported instruction compared with the conventional method of instruction on students' motivation. An independent sample t-test was employed to assess differences between the groups after the pre-test and post-test mean scores and standard deviations of the experimental and comparison groups were ascertained. A paired sample t-test was employed within the same group to examine the improvement in motivation from the pre-motivation to the post-motivation. Additionally**,** the collected data were typically analyzed using parametric statistical tests such as ANOVA, and Scheffes post-hoc analysis. The significance of differences between the mean scores and the mean differences of pre-motivation and post-motivation score was tested at the 0.05 level. The results of the research are tabulated according to the research questions and objectives of the study. The groups were compared with their pre- motivation questionnaire results whether they were different regarding to their prior motivation using ANOVA. Levene's test was used to determine homogeneity of variance, and skewness and kurtosis were used to presume that the data were normal.

RESULTS

Descriptive statistics on the pre-motivation likert scale of all the group students' motivation for geometry are as displayed in Table 2.

Table 2. The Descriptive statistics of pre- and post-motivation (its components) of the all groups

DV	Group	N	M	SD	SE	95% confidence interval for mean	
						Lower Bound	Upper Bound
Pre-motivation	EG1	42	3.9206	.50235	.07751	3.7641	4.0772
	EG2	42	3.7817	.51861	.08002	3.6201	3.9434
	CG	44	3.8346	.44063	.06643	3.6691	3.9370
Post-motivation	EG1	42	4.02	.49	.08	3.864	4.174
	EG2	42	3.83	.51	.08	3.671	3.992
	CG	44	3.56	.37	.05	3.447	3.672

Table 2 above indicates that before any treatment was given the means scores of pre-motivation were different among the groups while after treatments were given in post motivation EG1 student have higher mean score than EG2 and CG students in post motivation.

The Analysis of group differences on the pre- motivation

The objective of this subsection is to determine the results of GeoGebra supported instruction on students' motivation about geometry and the findings are presented in inferential statistics. Prior to conducting any statistical tests, the normality of the assumptions on the pre-motivation (its components) must be checked to determine whether the data is parametric or not. Due to their simplicity, skewness and kurtosis are used to check for normality in the data obtained from pre-motivation and post-motivation questioners. Levene's test of variances is used to determine whether a variance is homogeneous.

Table 3 : The Skewness and kurtosis of Students' Pre- motivation and its components

DV	Group	N	Skewness	Kurtosis	Levene's test	
					F	p
Motivation	EG1	42	-.168	-.495	.431	.651
	EG2	42	-.594	.607		
	CG	44	-.395	.405		
Intrinsic	EG1	42	-.596	.218	2.769	.067
	EG2	42	-.908	.570		
	CG	44	-.407	.598		
Extrinsic	EG1	42	-.350	-.446	.860	.426
	EG2	42	-.442	.160		
	CG	44	-.395	.405		
Task value	EG1	42	-.102	-.298	1.998	.140
	EG2	42	-.066	-.025		
	CG	44	-.027	.000		
Self-efficacy	EG1	42	.163	-.765	2.709	.071
	EG2	42	-.271	-.299		
	CG	44	.292	-.289		

From table 3 above, it can be seen that the data are normally distributed because the values of skewness and kurtosis in the pre-motivation (its component) are between -2 and 2 (George & Mallary, 2010). Levene's test results also showed that there is no substantial difference in pre-motivation across its components. After the assumptions of parametric tests were checked, a one-way ANOVA was employed to test the similarity between the groups before the interventions were administered.

Table 4. ANOVA result comparing groups in terms of pre- motivation and its components

DV		Sum of Squares	df	Mean Square	f	Sig.
Motivation	Between Groups	.472	2	.236	.993	.373
	Within Groups	29.722	125	.238		
	Total	30.192	127			
Pre-intrinsic	Between Groups	.178	2	.089	.265	.768
	Within Groups	41.891	125	.335		
	Total	42.069	127			
Pre-extrinsic	Between Groups	.906	2	.423	1.778	.173
	Within Groups	31.843	125	.255		
	Total	32.749	127			
Pre-task value	Between Groups	.404	2	.202	.611	.545
	Within Groups	41.319	125	.331		
	Total	41.722	127			
Pre-self-efficacy	Between Groups	.376	2	.188	.509	.602
	Within Groups	46.116	125	.369		
	Total	46.492	127			

As shown in Table 4 above, the ANOVA analysis table shows that there was no statistically significant mean difference between the three groups in pre-motivation (F (2, 127) =.993, p =.373). Pre-intrinsic score F (2, 127) =.265, p =.768, pre-extrinsic score F (2, 127) = 1.778, p =.173, pre-task value score F (2, 127) =.611, p =.545, pre-self-efficacy score F (2, 127) =.509, p =.602. This means that the groups were assumed to be the same in their motivation and its components before the implementation of the interventions.

H0 [1]: There are no significant differences between the scores of the post motivation (its components) of students across the three groups

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Table 5. ANOVA outcomes comparing the groups' post-motivation and its component parts

DV		Sum of Squares	df	Mean Square	f	Sig.
Motivation	Between Groups	4.608	2	2.304	10.69	.000
	Within Groups	26.94	125	.216		
	Total	31.548	127			
Post intrinsic	Between Groups	8.689	2	4.345	10.492	.000
	Within Groups	51.763	125	.414		
	Total	60.452	127			
Post extrinsic	Between Groups	.608	2	.304	.802	.451
	Within Groups	47.416	125	.379		
	Total	48.025	127			
Post task value	Between Groups	7.199	2	3.60	9.824	.000
	Within Groups	45.801	125	.366		
	Total	53.00	127			
Post self-efficacy	Between Groups	8.079	2	4.039	5.017	.008
	Within Groups	100.64	125	.805		
	Total	108.719	127			

The result of the ANOVA shown in Table 5 above indicates whether or not offering geometry-supported learning considerably increased students' motivation in all groups. Accordingly, the analysis of ANOVA F (2, 125) =10.69, P =.000 at p <.05; F (2, 125) = 10.492, P =.000 at p <.05; and F (2, 125) =.805, P =.451 at p >.05; F (2, 125) = 9.824, P =.000 at p <.05; and F (2, 125) = 9.824, P =.008 at p <.05 were for post motivation, post-intrinsic, post-extrinsic, post-task value, and post-self-efficacy scores towards learning geometry, respectively. This indicates that there was a statistically significant difference among the EG1, EG2, and CU groups in students' motivation in geometry after intervention. Since there was a significant difference between the three groups, the post hoc analysis test was computed to identify which group had a difference.

Table 6. Scheffe's posthoc test multiple comparison result

DV	(I) Group	(J) Group	Mean Difference (I – J)	SE	Sig.
Post-motivation	EG1	EG2	.187 *	.101	.002
		CG	.459*	.100	.000
	EG2	CG	.272*	.100	.023
Post-intrinsic	EG1	EG2	.123*	.140	.032
		CG	.600*	.138	.000
	EG2	CG	.476	.138	.920
Post-Extrinsic	EG1	EG2	.111*	.134	.040
		CG	.165*	.132	.000
	EG2	CG	.054	.132	.920
Post-task value	EG1	EG2	.107	.132	.445
		CG	.503*	.130	.001
	EG2	CG	.495*	.130	.001
Post-self -efficacy	EG1	EG2	.514*	.195	.035
		CG	.552*	.193	.019
	EG2	CG	.038	.193	.810

The above Table 6 shows that the mean score of EG1 differed significantly from the mean score of CG (p =.000, p <.05) in intrinsic, extrinsic, task-value, and self-efficacy after the intervention, with mean gains of 123, 111, 107, and 514, respectively. This result indicated that students exposed to EG1 (i.e., GSCM) have improved motivation towards learning geometry compared to the convectional approach, which has improved its components. Moreover, EG1 differed significantly from the mean score of EG2 (p <.05) in intrinsic, extrinsic, task-value, and self-efficacy with mean gains of.315, .336, .419, and .306, respectively. The result of Scheffe's posthoc shows there is a statistically significant mean difference in post-motivation between EG1 students and other groups. This indicates the GSCOM groups are better motivated than the other two groups.

Additionally, the results of the post hoc multiple comparisons demonstrated that, in terms of learning geometry, there was no statistically significant mean difference between the convectional technique and EG2 (i.e., the GSCM approach) at p >.05. It is clear from this that the intervention was effective in enhancing students’ motivation to learn geometry. Therefore, it can be said that integrating technology into a collaborative learning environment works better than both approaches. The main explanation is that students were able to learn in a creative, engaging, and visible way due to using technology. GeoGebra used within the collaborative approach assisted students to understand geometric concepts with concrete, real-life examples through visualization.

Analysis of Group Differences of pre-post motivation

A paired-sample t-test was used to test the hypothesis and compare the means of pre- and post-motivation and its components taken from the two groups. This can be highly helpful in determining how well a treatment works according to different instructions. The data gathered from the participants was impartial and dispersed equally.

$H_{0[1]}$: There is no significant difference between the mean score of pre- and post-motivation of GeoGebra -assisted instruction combined with conventional approaches.

Table 7 : Paired sample t-test for pre/post -motivation with in GeoGebra assisted learning with the conventional method

		Mean	SD	SE	T	df	p	Cohen's d
Pair 1	Post-pre intrinsic	.07727	.48266	.07276	-.062	43	.294	0.91
Pair 2	Post-pre extrinsic	.06356	.44184	.06661	.954	43	.345	0.28
Pair 3	Post-pre task value	.00379	.34754	.05239	-.072	43	.943	0.2
Pair 4	Post-pre self-efficacy	.06364	.47402	.07146	.891	43	.378	0.26
Pair 5	Post-pre total	.11266	.65568	.09885	1.140	43	.261	0.34

The above table shows that the paired sample t-test between the students' pre- and post-motivation reveals t (43) = 1.140, p =.261 as evidence in favor of this, indicating that the mean scores of the students' post-pre-motivation when learning through GeoGebra-supported learning with conventional methods do not differ significantly. This demonstrates that the GeoGebra software does not improve students' motivation to learn geometry, even when it supports the conventional lecture technique. This could result from a lack of interest on the part of the students in learning mathematics in general or in using GeoGebra-supported learning in combination with conventional methods. The following hypothesis demonstrates how pre- and post-motivation varies when using a collaborative approach in conjunction with GeoGebra-supported learning.

$H_{0[2]}$: There is no significant difference between mean score of pre- and post-motivation of GeoGebra supported learning in combination with collaborative method.

Table 8. Paired sample t-test for pre/post -motivation with in GeoGebra assisted learning with the collaborative method group.

		Mean	SD	SE	T	df	p	Cohen's d
Pair 1	Post-pre intrinsic	. 32381	.99359	.15331	2.122	41	.041	0.65
Pair 2	Post-pre extrinsic	.21429	.61627	.09509	2.253	41	.030	0.69
Pair 3	Post-pre task value	.43254	.79297	.12236	3.535	41	.001	1.085
Pair 4	Post-pre self	.24286	.64700	.09983	2.433	41	.019	0.75
Pair 5	Post-pre total	.28904	.66777	.10304	2.805	41	.008	0.86

A paired samples t-test presented in Table 8 depicted students' total pre- and post-motivation to learn geometry (t (41) = 2.805, P =.008, p <.05). This indicates that there is a statistically significant mean difference between total motivation and component motivation. The result highlights that students who learned geometry with GeoGebra -supported based learning with a collaborative approach were more likely to attain better motivation towards geometry. The effect size, Cohen's d = 0.86, shows a large effect size. As a result, students exposed to the GeoGebra integrated collaborative method performed better in learning geometry.

On top of this, the researcher used independent sample t-test in order to test the significance of mean difference between post-motivation of GeoGebra supported learning in combination with collaborative method and traditional lecture method of the following hypotheses were checked.

Table 9. Independent sample test of the mean score difference of the post -motivation across the group

	Group	Mean	SD	SE	t	df	p
	EG2	3.3476	.92136	.14217			
Post –total	EG1	4.1382	.43938	.07484	82	2.328	.022
	EG2	3.9032	.48468	.14217			

Table 9 shows that the mean score of EG1 students is greater than mean score of EG2 students across all components of motivation. However, the result of the independent samples t-test indicates that there is a statistically significant different between each components of motivation across the groups. This implies that learning geometry supported by GeoGebra does bring a significant difference to students' motivation to learn geometry. In supporting to this, various studies reveal that utilization of software technology increases students' motivation (Tegegne, 2014b; Mulugeta, Zelelem & Kassa, 2015). There is a positive relationship between technology and students, and also there is a direct association between motivation and learning mathematics (Shin & Mills, 2011).

DISCUSSION

This study was done to investigate the effects of GeoGebra -supported learning with a collaborative approach, GeoGebra -supported learning with a convectional approach, and the convectional approach on students' motivation toward learning geometry. The ANOVA analysis of the pre-motivation results showed that there was no significant difference between the three groups ($p > .05 = .373$), indicating the groups shared similarities. The post-motivation ANOVA result shows there is a significant difference between the GSCOM, GSCM, and CU groups. According to this post-motivation score analysis, GSCOM students outperform both GSCM and CG students in terms of improving motivation toward learning geometry ($p = .000$). This improvement in motivation could be due to a variety of reasons. In the GSCOM group, students do all the activities in groups with the help of GeoGebra software. In this process, the students construct their own knowledge rather than just memorize geometry rules and formulas in small groups, which create motivation for them. The other two groups did not have the opportunity to discuss, learn, and work together. The fact that the abstract geometry learning was illustrated and that the GSCOM group was able to fully understand the material more thoroughly when they studied with the help of GeoGebra is another factor contributing to their improved motivation. This shows that using GeoGebra software with group discussion and practical exercises improved students' motivation and level of understanding in geometry. On the other hand, convectional group students are generally restricted to text books and to memorization of geometry rules and formulas while learning and doing exercises. Students have not had enough opportunities to create their own learning using a collaborative group. This may be the reason why students had less motivation than other group students.

Furthermore, to compare students' geometry learning between pre- and post-motivation and determine whether there had been a substantial improvement, the paired sample t-test results were also essential. The result showed that the post-motivation scores of secondary school students who were taught with the GSCOM approach were significantly higher at the end of the course than pre-intervention. Following the intervention, the experimental group's motivation improved. Moreover, Table 7 shows that Cohen's $d = 0.34$ indicates the effect size, which is a small influence, and in the same manner, Table 8 shows Cohen's $d = 0.86$ indicates a strong or a significant effect of the experimental group. As a result, students treated to the GeoGebra integrated collaborative method performed motivationally more than students treated to the GeoGebra integrated convectional method and convectional method only, and students exposed to the GSCM performed motivationally better than students exposed to the conventional method. These differences are also caused by the fact that students are likely to be highly motivated when the collaborative teaching method is delivered in conjunction with GeoGebra.

This result is consistent with certain research findings. In light of this, Abera (2015) revealed that technology-supported instruction is a great way to improve students' motivation and problem-solving skills. In addition, the findings of Tegegne (2014) and Mohammed (2014) show that using software technology in teaching and learning improves students' motivation to learn mathematics. Moreover, the study of Hagos & Andargie (2023) shows that regular use of technology-integrated learning and evaluations by teachers has the potential to raise student motivation and enhance learning outcomes. Incorporating technology tools and software also makes learning easier and enhances the lesson's interest, enjoyment, and educational value. In a similar study, Faber et al. (2017) discovered that classroom instruction aided by technology significantly increased secondary school students' motivation to learn. According to Sivin-Kachala and Bialo (2000), using computers to teach mathematics can improve students' confidence and motivation. The result of this study also validate the findings of (Gambari et al., 2016) who found that students who exposed to computer based instruction have higher level of intrinsic and extrinsic motivation and learning achievement than conventional method. This result showed a good correlation with students' motivation for studying geometry when exposed to GeoGebra-based classroom instruction.

Contrary to the above findings, the study by Gemechu et al. (2018) demonstrates that there is no discernible variation in the motivation of students and its component to learn mathematics when using software-supported learning and teaching of the subject. Additionally, this study concludes that students' motivation to learn mathematics through instruction supplemented by mathematical software does show significant impact on motivation. Similar to this, Wong & Wong, 2021), argued that the use of proper technology to supplement classroom education did not significantly increase motivation.

In the contemporary world, education and technology have long been considered the main forces behind human progress. However, instead of using a classical education system, it is essential to implement one that involves learning by integrating technology in the twenty-first century. Compared to using pencil and paper, students who use computer-supported learning are considerably more motivated to study. Today's education is thought to be a step forward. One may contend that the integration of technology with the instructional approach in the classroom has increased students' motivation and involvement in mathematics studies.

CONCLUSION AND RECOMMEDATIONS

The study investigated the effect of GeoGebra -assisted learning on students' motivation in tenth grade geometry learning. In light of the findings, consequently, it can be concluded that students exposed to GeoGebra –supported learning with a collaborative approach have higher motivation and are more engaged in certain geometrical tasks than students exposed to GSCM and traditional paper-pencil instruction. These methods encouraged the secondary school students to learn the topics by visualizing abstract geometrical concepts. Therefore, the researcher strongly believed that using a collaborative approach integrated with GeoGebra could improve students' motivation to learn geometry relative to other instructional methods. However, this study was limited only to the impact of GeoGebra supported instruction on students' motivation towards learning geometry. This implies that there is a need for further studies on other variables such as students' problem solving, attitude, and the like, and other fields of mathematics.

The following recommendations are made in light of the study's findings:

- Secondary school mathematics teachers, mathematics curriculum developers, and other stakeholders should pay attention to GeoGebra instructional approaches integrated with collaborative learning as they improve students' motivation. The use of this technology in collaboration with the active learning method should be used to close the academic gaps in learning mathematics.
- Curriculum planners should design textbooks for students based on technology supported collaborative learning that is integrated into the curriculum. To enhance students' motivation, they should incorporate technology into the secondary school curriculum.
- In teacher training institutions, mathematics teachers should be taught not only how to use technology but also how to integrate software with active learning methods in mathematics lessons for efficiency in teaching.

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